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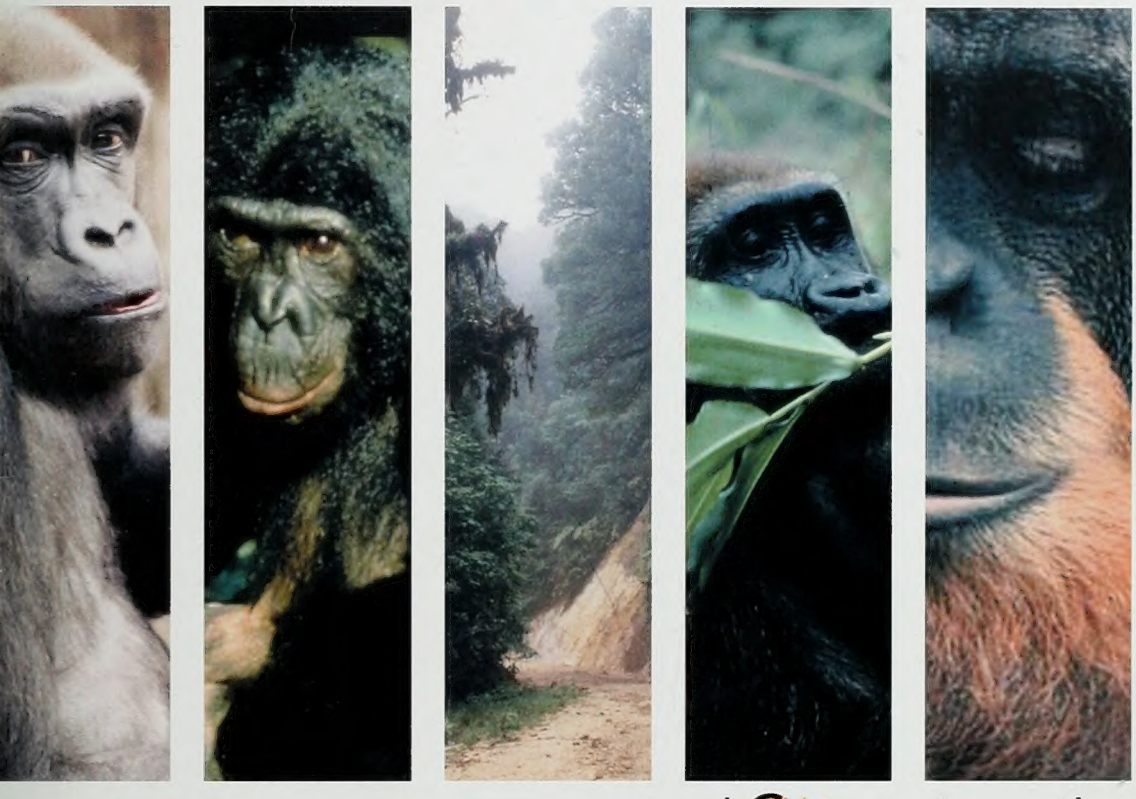
THE GREAT APES – *the road ahead*



A GLOBIO *perspective*
on the impacts of
infrastructural development
on THE GREAT APES

UNEP

Front cover photos

Left to right: Daniel O'Brien/UNEP/Topham; Born Free Foundation/I Redmond; G Brower/UNEP/Topham; Born Free Foundation/I Redmond; Tan Yik Yee/UNEP/Topham.

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THE GREAT APES – *the road ahead*

A GLOBIO *perspective*
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infrastructural development
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Preface

UNEP

Dr. Klaus Toepfer, Executive Director, United Nations Environment Programme

The great apes are on the brink of extinction. The loss of our closest relatives on Earth would not only be a great tragedy, it would signify the demise of entire ecosystems and the people who rely on them. The fate of the great apes has great symbolic implications for mankind's ability to develop a more sustainable future.

The destruction of the forests of Indonesia and Africa has enormous costs for biodiversity, but also for people living in poverty and under political instability, thereby threatening their access to food and medicine. For many indigenous people, it also means the loss of traditional lifestyles and their cultural identity.

Roads are being built in the few remaining pristine forests of Africa and Southeast Asia to extract timber, minerals and oil, often by companies based in the industrialized world. Uncontrolled road construction in these areas makes increased bushmeat hunting and deforestation possible.

This report suggests the possible fate of the great apes and their habitats, if current trends continue. It is not too late to stop uncontrolled exploitation of these forests. By doing so, we may save not only the great apes, but also thousands of other species. We will also help protect the livelihoods of the many people that rely on these forests for food, medicine and clean water. Protecting the great apes is not just about protecting forests and biodiversity, but about the future of us all.

Luis Pinto/UNEP/Topham

Construction of roads in forest areas is of particular importance, as such development may increase logging, hunting, mining, plantation establishment, agriculture and industrial development and access by bushmeat hunters, which are all factors threatening great ape populations.

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Executive Summary

The great apes, including the chimpanzee, gorilla and orangutan, are threatened with extinction. All species are rapidly declining in abundance, even within protected areas. For example, in a survey of 24 protected areas in Africa and Southeast Asia, great ape populations are declining in 96% of these sites.

The main factors responsible for decline in great ape species are loss and degradation of habitat, and hunting. Construction of roads in forest areas is of particular importance, as such development may increase logging, hunting, mining, plantation establishment, agriculture and industrial development and access by bushmeat hunters, which are all factors threatening great ape populations.

This report assesses the impact of infrastructural development on great ape populations, using the GLOBIO modelling approach. GLOBIO is a multivariable spatial model, which estimates the extent of land area with reduced abundance and diversity of living organisms, as a result of infrastructural development. The model can also be used to develop scenarios of possible future impacts, based on the current rates of infrastructural development.

Results of GLOBIO analyses indicate that more than 70% of the habitat of each of the African great ape species has been negatively affected by infrastructural development. For orangutan, the corresponding figure is 64%.

Future scenarios suggest that the annual loss of undisturbed habitat will be greater than 2% per year in the case of the African great apes, and 5% in the case of the orangutan, in Southeast Asia. By 2032, the scenarios suggest that less than 10% of great ape habitat in Africa will remain free of the impacts of infrastructural development. In the case of orangutan, the corresponding figure is less than 1%. These figures are supported by estimates of habitat loss and degradation made independently, by great ape field researchers.

Urgent action is required by the governments of great ape range states, with financial and political support from the international community, to ensure the future survival of great apes.

Introduction

In recent years, great ape species have declined at an alarming rate (Butynski 2001, Robertson and van Schaik 2001). One of the main reasons for this decline is intensive exploitation of natural resources in some of the areas where great apes live. The habitats of the great apes contain valuable economic resources such as timber, minerals and oil. In order to access these resources, extensive infrastructural development, particularly roads, has occurred in many tropical areas, resulting in fragmentation of great ape habitats.

The development of road networks, which in tropical areas are often designed explicitly to access natural resources, has resulted in many environmental impacts (Turner 1996). Tropical forests have been deforested by an average of approximately 1.8% annually in African great ape range states during 1990-2000, and by an average of approximately 1.2% annually in Southeast Asia during the same period (FAO 2001). By increasing access by people to previously inaccessible areas, and by fragmenting habitat, road development is a major cause of biodiversity loss (Turner 1996, Angelsen and Kaimowitz 1999, Wilkie et al. 2000). Roads intended for oil, gas, mineral or fibre extraction can result in extensive uncontrolled immigration, with resultant increases in illegal logging, hunting and poaching of animals, transport of bushmeat, slash and burn agriculture, and conflicts with local communities (Andrews 1990, Angelsen and Kaimowitz 1999, Forman and Alexander 1998, Houghton 1994, Kummer and Turner, 1994, Lambin et al. 2001, Mäki, Kalliola and Vuorinen 2001, Reid and Bowles 1997, Robertson and van Schaik 2001, Trombulak and Frissell 2000, Wilkie et al. 2000, UNEP 2001; see http://www.globio.info/ for further review).

Scope of this report

In this report, we provide a preliminary assessment of the impacts of infrastructural development on the great apes, using the GLOBIO method. This work has been undertaken as part of an ongoing effort to assess the current status of great ape species, and the pressures that affect them, in support of the Great Ape Survival Project (GRASP) coordinated by UNEP. In the future, we aim to refine the assessment as improved information on the status and distribution of great apes becomes available through preparation of the *World Atlas of Great Apes* (see Annex 2). This report should therefore be viewed as a work in progress. The editors welcome comments, suggestions and contributions as the work progresses during development of the atlas.

Ling Chi Hung/UNEP/Topham

Roads in developing countries are often built with capital input from multinational companies and economic networks based in the industrialized world.

The GLOBIO method

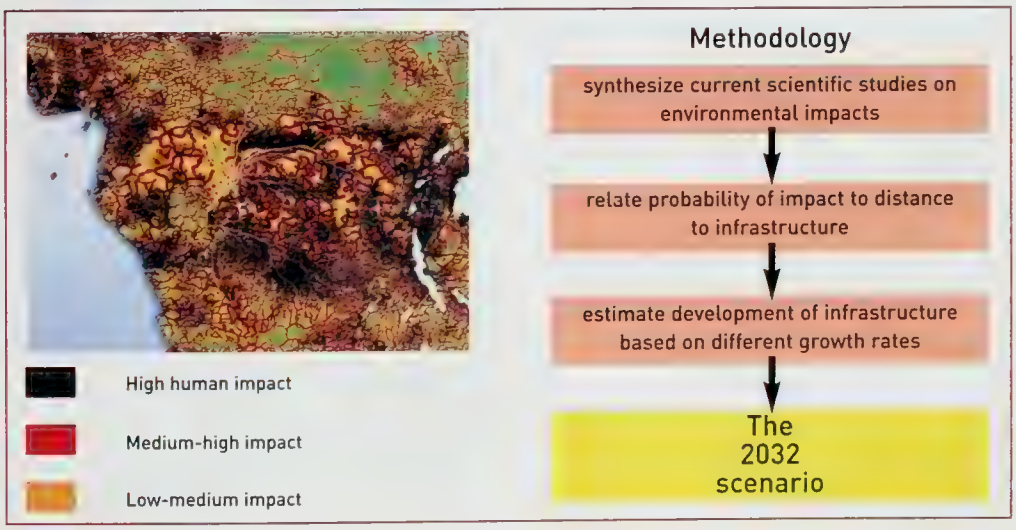
The GLOBIO2-model is being developed for and together with the United Nations Environment Programme (UNEP) to help assess and map the environmental impact of human development (UNEP 2001). GLOBIO2 is a distance-related multivariable buffer-based model for estimating the extent of land area with reduced abundance and diversity of living organisms, as a result of infrastructural development. The model can also be used to develop scenarios of possible future impacts. The model incorporates buffer zones of probability of reduced abundance of wildlife occurring around infrastructure features, such as roads, major trails, human settlements, industrial features such as power lines, dams, etc.

Data sets were compiled on a global 1 x 1° longitude-latitude grid system and included all linear infrastructure (major trails, roads, railroads, power lines and pipelines) in the DCW (VMAP level 0 and 1), land cover from USGS-GLCC2 based on AVHRR data from 1992-1993, population density from GPW, version 2, and resource databases on oil, gas and mineral reserves from ArctAtlas (see www.globio.info for more information).

For illustrative purposes, four zones of impact are defined based on the functional response of species to disturbance arising from infrastructural development, identified by a review of published research. For the review, the literature covered by the Current Contents/Agriculture, Biology and Environmental Sciences database was used as a source. Current Contents provides access to bibliographic information from articles, editorials, meeting abstracts, commentaries and all other significant items in recently published editions of over 1,040 of the world's leading agriculture, biology and environmental sciences journals and books (ISI net 2001). Article titles and keywords were searched for the terms landscape, habitat patch or patch, forest fragmentation, roads and disturbance from the period January 1987 to October 2001. In this review, experiments were excluded and only articles strictly based on empirical investigations published in journals, relating to fragmentation or disturbance effects associated with roads, human traffic or activity were included, giving a total of 309 articles on the issue of disturbance from roads. This overview was cross-checked against recent literature reviews.

Based on these articles[1], the zones of impact were defined statistically, based upon the distribution of declining species within different distance categories to roads:

- "high impact" – upper 50th percentile (i.e. the distance interval within which >50% of all species that decline by >50% are found);
- "medium-high impact" – 25-50th percentile (the distance interval within which 25-50% of all recorded species that decline by >50% are found);
- "medium-low" impact – 1-25th percentile (the distance interval within which 1-25% of all recorded species that decline by >50% are found), and
- "low impact" (for areas beyond those distances).



Distance zones with an estimated reduction in abundance of vertebrates vary with type of infrastructure (utilities, tracks and trails have 50-75% lower impact zones) (see www.globio.info), land cover, climatic region and population density, and are based on literature surveys linking risk of decline in wildlife to distance to infrastructure using regression analysis. These impacts are often related to such factors as land and water degradation, conversion of land, fragmentation or hunting.

By using distance to infrastructure (and subsequent infrastructure density) as a measure of risk to biodiversity, it is possible to predict the approximate area of impact zones with associated road density in the future (by simple regression analyses using different alternatives of growth). If a projected growth implies a given annual increase in infrastructure density and built-up areas, the extent of the future impact zones away from existing infrastructure can be calculated as:

$IZ_j = \sum_{ij} [(IZ_c)P_{Tot\,i}] - A_{meiz}$;

where:

IZ_j = Impact Zone given as perpendicular distance away from infrastructure in the future year *j*;

IZ_c = Current Impact Zone given as perpendicular distance away from infrastructure in the current year (baseline);

$P_{Tot\,i}$ = Annual percent increase in growth predicted of IZ_c for the individual years *i*;

A_{meiz} = Geographical area/land cover of environmental impact zones that have merged.

Each unit was classified according to vegetation cover, oil, gas and minerals present in a 50 km radius, and density of infrastructure. The growth rate in infrastructure was then set as a function of these resources according to the following scheme: the growth potential is defined as:

$P_{Tot\,i} = B_g (P_{cgi})$;

where:

$P_{Tot\,i}$ = Annual percentual increase in growth predicted of IZ_c for the individual years *i*;

B_g = a baseline growth of 1%;

P_{cgi} = Product of multiplication constants for different distances to sea/coast (<50 km from coast) (1.25), croplands (1.0); grasslands (0.75); broadleaf/tropical forest (1.75); semi-deserts and deserts (0.5); wetlands (1.0), and mineral deposits, gas and petroleum reserves within a 50 km radius (1.5), and finally population density (0-10 / km^2 = 0.5; 10-50 / km^2 = 1.0; and >50 km^2 = 1.5), the ranking of which has been determined using outputs from multiple regression analysis.

For a given time period of i years the growth potential is quantified as: $P_{Tot\,i} = P_{Tot}^{(5i-50)}$.

For the development of future scenarios, the following assumptions were made, as defined by the rules presented above:

i) infrastructure primarily expands away from existing infrastructure and through further aggregation;

ii) infrastructural development will continue according to current rates of increase;

iii) areas with relatively high current population density will experience relatively high rates of growth in infrastructure;

iv) areas with known timber, oil, gas or mineral resources will experience relatively high rates of growth in infrastructure;

v) areas close to coasts will experience relatively high rates of growth in infrastructure.

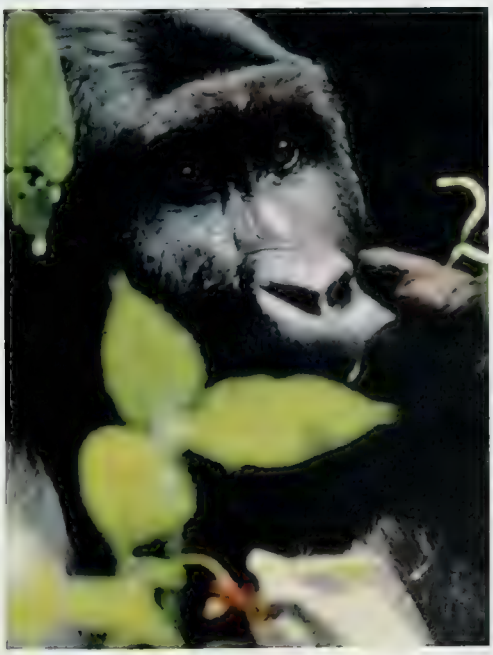
The rate of growth in infrastructure is estimated from historic changes in land use and road development based on data and projections obtained for different continents, for the period 1850-2000. For full details of the method, see http://www.globio.info

Studies demonstrating a relationship between habitat fragmentation and decline in abundance of species were also included in this analysis. Fragmentation of continuous forest into smaller more isolated patches generally follows road construction, and subsequent logging, deforestation and conversion into croplands (Angelsen and Kaimowitz 1999, Forman and Alexander 1998, Houghton 1994, Kummer and Turner 1994, Lambin et al. 2001, Mäki, Kalliola and Vuorinen 2001, Reid and Bowles 1997, Robertson and van Schaik 2001, Trombulak and Frissell 2000, Wilkie et al. 2000). Often the effects of roads on wildlife are presented as the critical area of habitat fragments (islands) below which species decline. Size of forest fragments is closely correlated with road density at regional scales; the more roads, the greater the fragmentation and the smaller the fragments (Aguilar et al. 2001). Here, we also included the results of fragmentation studies by taking the square root of the area of the fragment in km^2 below which a >50% decline in species abundance was recorded, as a measure of the impact zone from roads

The impact of infrastructural development on bonobo, chimpanzee and gorilla habitats

Born Free Foundation B Harris-Jones

Born Free Foundation/J Redmond

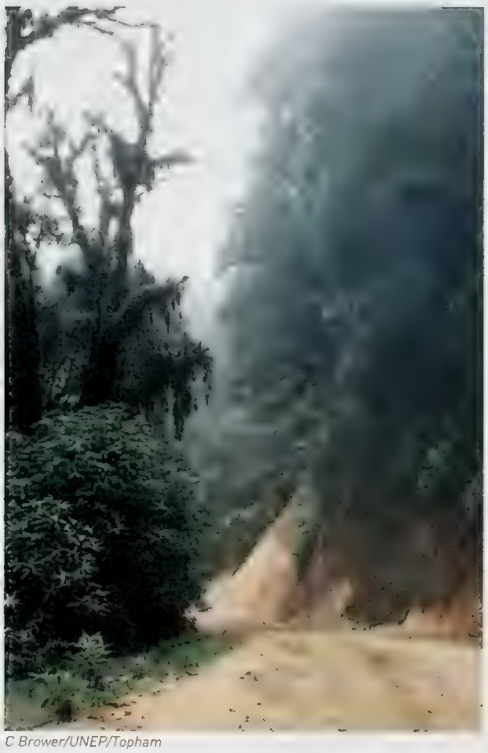


Born Free Foundation / Redmond

Two species of chimpanzee occur in Africa: the common chimpanzee (top left) *Pan troglodytes* (often shortened to chimpanzee) and the bonobo (top right) *Pan paniscus* (formerly known as the pygmy or gracile chimpanzee). Gorillas (bottom left) occur in a range of forest habitats in Africa. Populations are grouped in two main regions: equatorial West Africa and eastern Central Africa. These populations are sometimes referred to as full species, *Gorilla gorilla* and *Gorilla beringei* respectively (see Annex 1).

P. Aventurier/UNEP/Topham

Large-scale logging operations made possible through road construction can cause losses of the habitats of the great apes, as well other species.



C. Brower/UNEP/Topham

Road construction is one of the key factors threatening biodiversity and the remaining habitats of the great apes, by increasing opportunities for mining and oil extraction, bushmeat hunting and conversion of forest to agriculture.

Loss of suitable forest habitat is by far the greatest threat to both chimpanzees and gorillas, along with bushmeat hunting. Road development contributes to both, by improving access to hitherto inaccessible areas. Road construction can also promote habitat fragmentation, which can increase the risks to individual ape populations. The remnant populations of chimpanzee are primarily located in remnant forest, game reserves and national parks, but unauthorized hunting, logging, mining and farming are common in many nominally protected areas.

Table 1. Estimated numbers of remaining African great apes in the wild (source: Butynski 2001)

Species / subspecies	Latin name	Estimated number remaining
Western chimpanzee	*Pan troglodytes verus*	25,500-52,900
Nigeria chimpanzee	*P. troglodytes vellerosus*	4,000-6,000
Central chimpanzee	*P. troglodytes troglodytes*	47,500-78,000
Eastern chimpanzee	*P. troglodytes schweinfurthii*	75,200-117,700
Bonobo	*P. paniscus*	20,000-50,000
Western lowland gorilla	*Gorilla gorilla gorilla*	94,500
Cross River gorilla	*G. gorilla diehli*	200
Mountain gorilla	*G. beringei beringei*	324
Grauer's gorilla	*G. beringei graueri*	16900
Bwindi gorilla	*G. beringei (ssp.?)*	300

Insufficient data are available to define the rate of decline in abundance of the African great apes with any precision. However, a detailed survey of expert opinion was recently undertaken involving 34 ape field researchers. Data were collected from 24 protected areas in 11 countries that contain great ape populations (Marshall, Jones and Wrangham 2000). The data collected (Table 2) refer to the status of ape populations in protected areas where there is a dedicated research presence; this is where prospects for ape survival are most optimistic, and therefore these data significantly underestimate the overall magnitude of threats to great ape populations. These data indicate that even within such high-profile protected areas, 96% of field workers reported that the ape populations with which they are familiar are in decline. Eleven percent of the researchers consulted considered that their populations will have become extinct within the next 50 years; 72% of populations are expected to decline by at least 50%. Results also indicated that apes are hunted within 62% of all protected areas. Habitat loss and illegal logging were also cited as major threats to great apes (Marshall, Jones and Wrangham 2000).

Table 2. Percentage of protected areas with ape populations that are stable, declining and rising (source: Marshall, Jones and Wrangham 2000)

Ape species	% rising	% stable	% declining	No. of areas
Chimpanzee	0	9	91	11
Bonobo	0	16	83	6
Gorilla	0	0	100	7
Orangutan	0	0	100	3
All protected areas	**0**	**4**	**96**	**24**

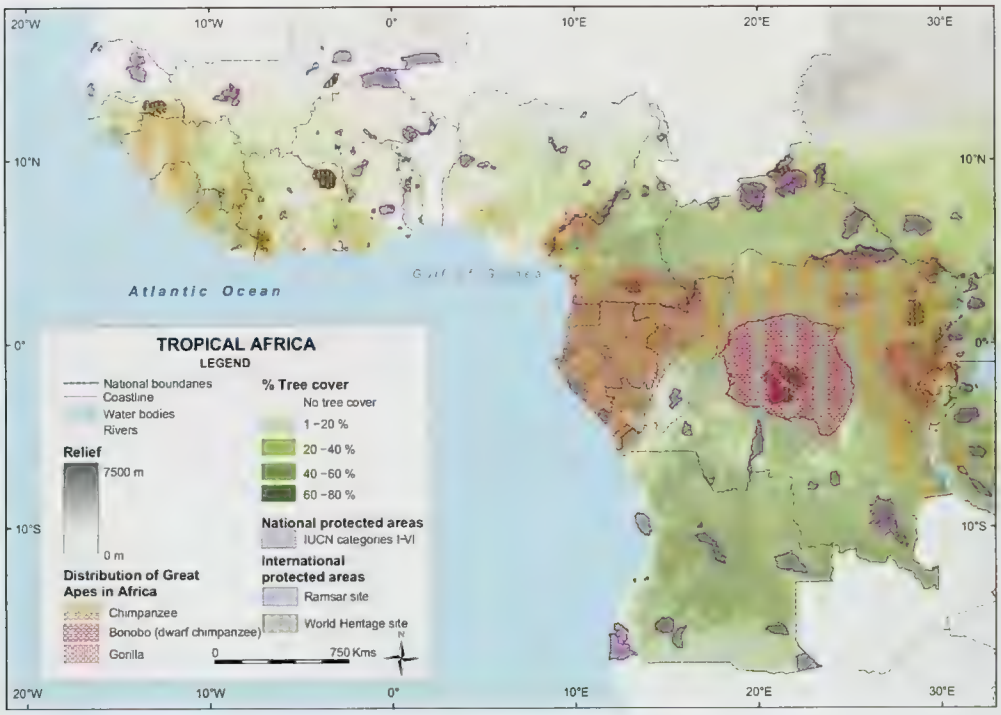


Figure 1. Distribution map of African great apes

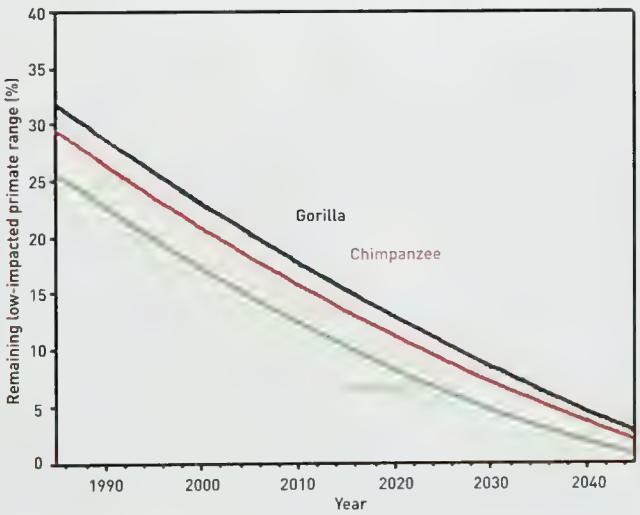
The range data presented here are derived from the African Mammals Databank (http://gorilla.bio.uniroma1.it/amd/index.htm), developed by the Istituto di Ecologia Applicata, Rome, Italy. These data are currently being updated, through collaboration with a range of partners, during preparation of the *World Atlas of Great Apes*. Protected Area data were derived from the database managed by UNEP-WCMC and the IUCN World Commission on Protected Areas. Forest cover data are based on remote sensing data (MODIS) and were kindly provided by the Earth System Science Interdisciplinary Center, University of Maryland.

The maps presented have been made using the GLOBIO2-model applied to the current ranges of the great apes (using data presented opposite in Fig. 1). The results are summarized below (Table 3, Fig. 2). These results indicate that less than 30% of habitat of each of the African great apes is currently classified as low impact, with respect to infrastructural development. Future scenarios suggest that the annual loss of such habitat will be greater than 2% per year, with less than 10% remaining in the low impact category by 2032. These figures compare with future estimates of habitat loss within protected areas of 3-14% for African great apes, during the next ten years, based on expert judgement (Marshall, Jones and Wrangham 2000). The results suggest that habitats of the great apes will decline rapidly in coming years, with a continuation of the current trend in logging, mining and associated road construction, associated land conversion and bushmeat hunting.

Table 3. The extent of habitat of African great apes that is relatively undisturbed (low-impact) by infrastructure development at present, and as projected by GLOBIO scenarios

Species	Low-impacted range in km² (%)		Estimated annual loss of current low-impacted range (km²) 2000-2032	Annual relative loss projected (% of current low-impacted range)
	Current	2032		
Gorilla	204,900 (28)	69,900 (10)	4,500	2.1
Chimpanzee	390,840 (26)	118,618 (8)	9, 070	2.3
Bonobo	96,483 (23)	17,750 (4)	2,624	2.8

Figure 2. Projected trends in the extent of habitat of African great apes that is relatively undisturbed (low-impact) with continued rates of road development (according to GLOBIO analyses)



The following maps illustrate the current and potential future impact of infrastructural development within the distributional areas of African great apes (Figs 3 and 4).

Figure 3. Current status of infrastructural development in Africa according to GLOBIO analyses
The areas in black, red and yellow are areas where species are likely to have declined as a result of infrastructural development (i.e. respectively high, medium-high and low-medium zones of impact, according to GLOBIO analyses).

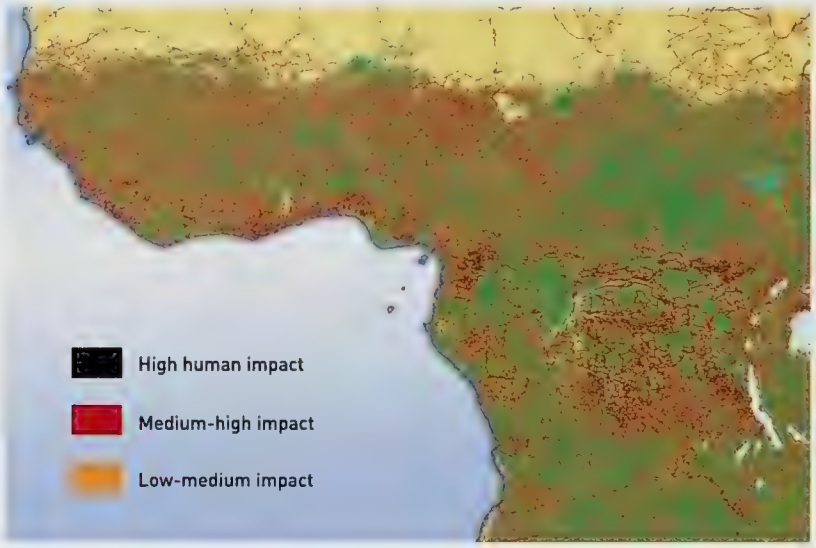
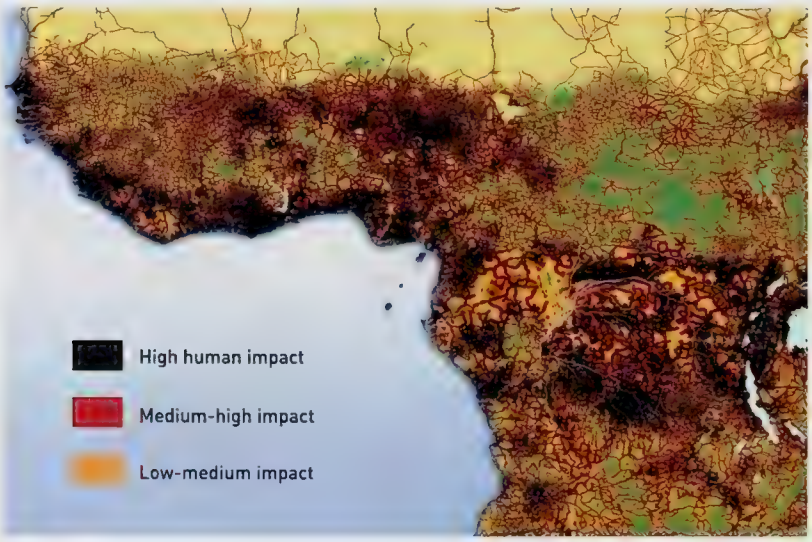


Figure 4. Future impact of infrastructural development in Africa according to GLOBIO scenarios for the year 2032
The areas in black, red and yellow are areas where species are likely to have declined as a result of infrastructural development (i.e. respectively high, medium-high and low-medium zones of impact, according to GLOBIO analyses).



The impact of infrastructural development on orangutan habitats

Tan Yik Yee/UNEP/Topham

Orangutans are the only great apes outside Africa, and occur in forested habitats on the islands of Borneo (Bornean orangutan, *Pongo pygmaeus*) and the Sumatran orangutan (*P. abelii*; see Annex 1 for more details). Division of Bornean orangutan into different subspecies is controversial. Recent analysis of morphological data suggests that three subspecies may exist (Groves 2002): *Pongo pygmaeus pygmaeus* is medium-sized and occurs in northwest Kalimantan and Sarawak; the largest subspecies, *P. p. wurmbii*, is found in southwest Kalimantan, and the smallest, *P. p. morio*, occurs in Sabah and east Kalimantan. Rivers form the main barriers between these divisions.

As in Africa, road construction promotes forest loss and degradation. Habitat loss, fragmentation and degradation are the major factors threatening orangutan survival. Human activities (logging, mining, plantation establishment, agriculture, road building, industrial development etc.) have caused the loss of anywhere between 25-50% of suitable orangutan habitat depending on region. Less than 14% of the official conservation and protected forest is suitable ape habitat (Rijksen and Meijaard 1999). Official timber concessions almost completely overlap the fragmented distribution range of the orangutan in Kalimantan and northern Sumatra. In eastern Malaysia large areas have been converted for plantations and logging has reportedly increased considerably during the last 10 years; 86% of forest land was conceded for timber concessions in 1986 (Rijksen and Meijaard 1999).

Fires have ravaged Kalimantan repeatedly over the past two decades and began burning again in 2002, most of them started by humans. Many start as forest intended for plantations and crops is cleared and burnt along road corridors. As infrastructure expands, these effects penetrate deeper into orangutan habitats. As a result of the fires, Rijksen and Meijaard (1999) believe Borneo's orangutan population was reduced from 23,000 in 1996 to 15,400 in 1998 – a decline of 33% in just one year.

Orangutans are unable to survive long-term in degraded and fragmented forests. Their fruit-dominated diet requires them to occupy large ranges to ensure sufficient supplies and some individuals commute between feeding sources. Devastated forests offer few fruit resources and orangutans are forced out to roam in search of food. Large numbers

were massacred while fleeing the flames and smoke during and after the extensive forest fires of 1997 and 1998. The displacement of apes can cause a 'shock wave' of refugee crowding in adjacent forests (Rijksen and Meijaard 1999), which can lead to increased physiological and psychological stress, and can have negative impacts on reproduction. Similarly, orangutan do not cope well with selective logging. Selectively logged forest and old secondary growth contain only 30-50% of the orangutan density found in primary forest (Yeager 1999).

Orangutans are a protected species over their entire distributional range and all hunting is illegal. Nevertheless, poaching is common in both Borneo and Sumatra. Poaching safaris (by army and industrial elites) reportedly take place and hunting is still common in rural and forest communities. Losses due to hunting and the pet trade may be sizeable and recent reports indicate an increase in poaching, primarily as a response to the economic crisis in Indonesia (Rijksen and Meijaard 1999). There is a regular trade in apes to ports in Java, Singapore, Bangkok, Hong Kong and Taiwan. Habitat loss resulting from road construction and associated logging, forest clearance and fires has exacerbated this problem, since it drives animals into increased contact with humans and into ever smaller habitat fragments, while increasing access to bushmeat hunters.

Table 4. Estimated population sizes of orangutan (source: Rijksen and Meijaard 1999, Hilton-Taylor 2000)

IUCN category	**Bornean Critically endangered**	**Sumatran Endangered**
Population size:		
Early holocene	420,000	380,000
1900	230,000	85,000
1996	23,000	12,000
1997 (after fires)	15,000	12,000
Future predictions	1,500-2,250	7,200

Table 5. Percentage of orangutan range that is relatively undisturbed (i.e. low-impact) by human activity and infrastructure development projected by GLOBIO scenarios

Species	**Low-impacted range in km² (%)**		**Estimated annual loss of current low-impacted range (km²) 2000-2032**	**Annual relative loss projected (% of current low-impacted range)**
	Current	**2032**		
Orangutan	92,332 (36)	424 (<1)	4,697	5

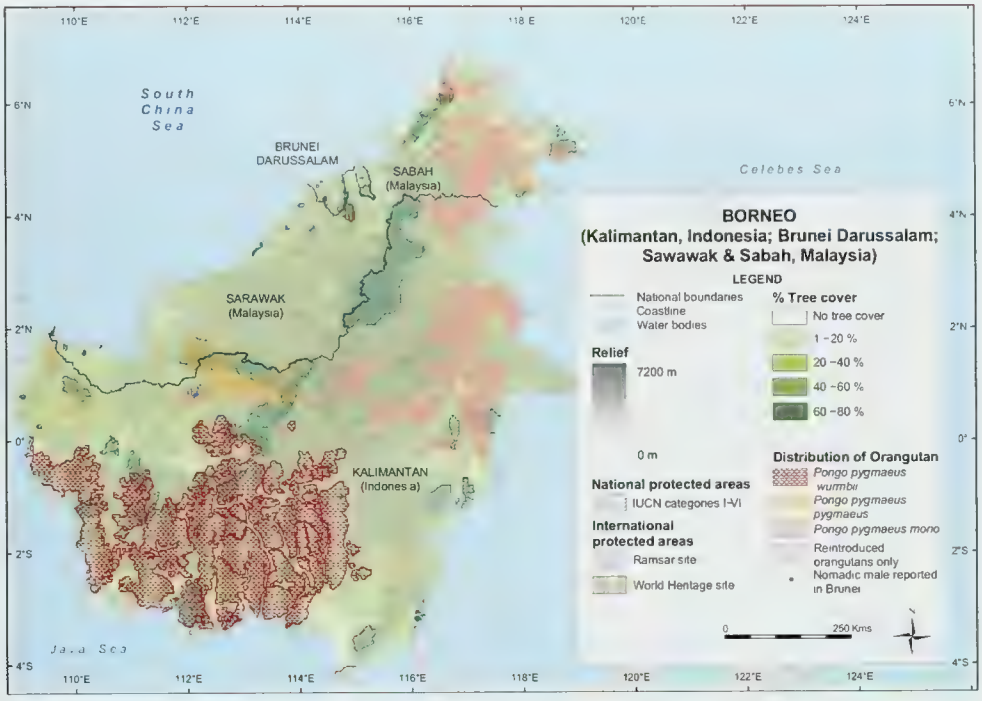


Figure 5. Distribution map of great apes in Borneo (above) and Sumatra (below)

The range data presented here are derived from Rijksen and Meijaard (1999). These data are currently being updated, through collaboration with a range of partners, during preparation of the *World Atlas of Great Apes*. Protected Area data were derived from the database managed by UNEP-WCMC and the IUCN World Commission on Protected Areas. Forest cover data are based on remote sensing data (MODIS) and were kindly provided by the Earth System Science Interdisciplinary Center, University of Maryland.

Paulus Suwito/UNEP/Topham

Roads make conversion of forests to farmland and plantations possible, including the deliberate use of controlled fire.

J Macedo de Souza/UNEP/Topham

Mining requires roads to access and transport minerals, often resulting in secondary, uncontrolled immigration, with subsequent conversion of forests into plantations, croplands and, hence, loss of great ape habitat.

The forests of the great apes are also home to a broad range of indigenous people, who rely on the forests for medicine, shelter, food and their cultural identity.

CB Hansen/UNEP/Topham

When roads are built to increase access to timber, minerals, oil or gas, deforestation and fragmentation of great ape habitat can often result.

BYE Pyle/UNEP/Topham

The maps presented have been made using the GLOBIO2-model applied to the current ranges of the great apes (using data presented in Fig. 5). The results are summarized in Table 5 and Figs 6 and 7. These results indicate that approximately 36% of orangutan habitat is currently classified as low impact, with respect to infrastructural development. Future scenarios suggest that the annual loss of such habitat will be 5% per year. These figures compare with estimates of habitat loss within protected areas of 47% for orangutan, during the next ten years, based on expert judgement (Marshall, Jones and Wrangham 2000). These results suggest severe loss of orangutan habitat in coming decades, with less than 1% of habitat undisturbed by infrastructural development by 2032 (Figs 6 and 8).

Figure 6. Expected trends in the extent of habitat of Southeast Asian great apes that is relatively undisturbed (low-impact) according to GLOBIO analyses

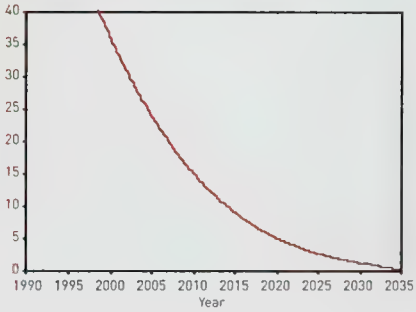


Figure 7. Current status of infrastructural development in Southeast Asia according to GLOBIO analyses

The areas in black, red and yellow are areas where species are likely to have declined as a result of infrastructural development (i.e. respectively high, medium-high and low-medium zones of impact, according to GLOBIO analyses).

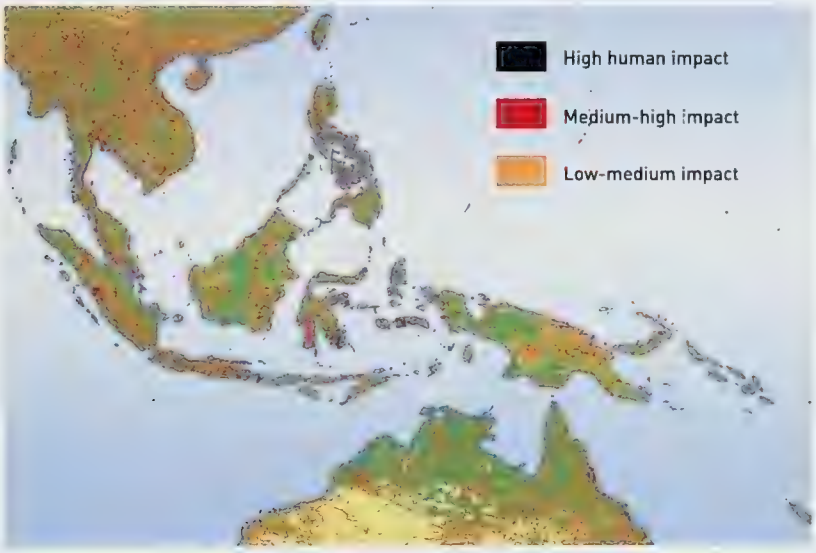
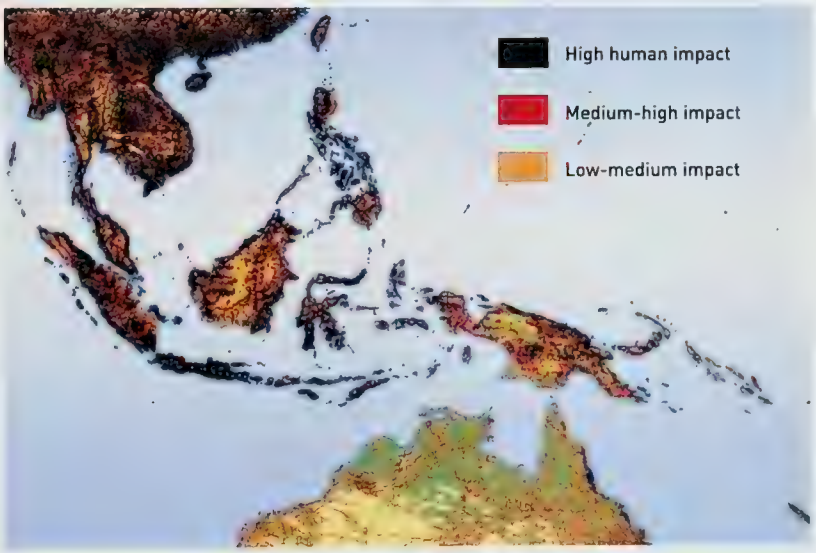


Figure 8. Future impact of infrastructural development in Southeast Asia according to GLOBIO scenarios, for the year 2032

The areas in black, red and yellow are areas where species are likely to have declined as a result of infrastructural development (i.e. respectively high, medium-high and low-medium zones of impact, according to GLOBIO analyses).



Conclusion: Great apes, the road ahead

All great ape species are currently considered to be threatened with extinction. There is an urgent need to address the main threats to ape populations: the loss and degradation of habitat, and hunting (Butynksi 2001, Rijksen and Meijaard 1999). Human activities such as logging, mining, plantation establishment, agriculture and industrial devel-opment, which are all factors threatening great ape populations, are facilitated by road construction.

Although roads may often be built for industrial purposes, they may directly or indirectly result in exploitation and conversion of great ape habitat, and increase the access by poachers and bushmeat hunters to formerly inaccessible areas. These roads are often built with capital input from multinational companies and economic networks based in the industrialized world.

The current analyses suggest that if current trends continue, infrastructural development will have a major impact on remaining great ape populations within coming decades.

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Annex 1
Status and distribution of great apes

Current status and distribution of African great apes

We provide here a brief summary of the current status and distribution of great ape species. For an authoritative, recent account of the African apes, the reader is advised to consult Butynski (2001); for Southeast Asian apes, a valuable recent account is provided by Rijksen and Meijaard (1999). A detailed account of each species is being prepared for the forthcoming *World Atlas of Great Apes*, currently in development. The text presented here should therefore be viewed as preliminary in nature.

Chimpanzee

Two species of chimpanzee occur in Africa: the common chimpanzee *Pan troglodytes* (often shortened to chimpanzee) and the bonobo *Pan paniscus* (formerly known as the pygmy or gracile chimpanzee). There is significant overlap in size between the chimpanzee and the bonobo, but the latter is more gracile in build, with a smaller, rounder skull, and a flatter face with less-prominent brow ridges. It is a highly social animal, and can exist in large groups in which females maintain strong bonds with other females.

The chimpanzee has a wide but discontinuous distribution in Equatorial Africa from Senegal in the west to Tanzania in the east (Fig. 1). Most taxonomists have recognized three or four distinct subspecies, although current genetic studies appear likely to refine this picture significantly. The western subspecies, *P. t. verus*, once occurred in 13 countries from southern Senegal east to the Niger River in central Nigeria, but the range has greatly diminished. Populations between the Niger River in Nigeria and the Sanaga River in Cameroon have recently been described as a separate (fourth) subspecies, the Nigeria chimpanzee *P. t. vellerosus*. The central subspecies, *P. t. troglodytes*, occurs from north Cameroon to the Ubanghi River and south to the Congo River. The eastern subspecies, *P. t. schweinfurthii* is found from the confluence of the Ubanghi and Congo rivers in western Democratic Republic of Congo eastwards to the southern end of Lake Tanganyika in Tanzania, and from there northwards to Burundi, Rwanda, Uganda and southern Sudan. Substantial numbers may exist in unsurveyed areas of eastern Democratic Republic of Congo, but elsewhere populations are small and scattered. No formal subspecies are currently recognized within the bonobo, which has a relatively wide but markedly discontinuous distribution in the central Congo basin, south of the Congo River. It occurs in forests around the Lomami River, the Kasai-Sankuru Rivers, and in the Lake Tumba-Lac Ndombe region, although it appears to be absent from the central part of this area between the Momboyo River and the Busira River. It had been thought that the species' range was continuous within this large forest zone, totalling approximately 340,000 km^2, but field observations since the 1970s indicate that it is absent or rare in many areas and common only in a few scattered localities. Studies in the last decade have confirmed viable populations near the towns of Befale, Djolu, Bokungu and Ikela, and in a 3,000 km^2 area between the Yekokora and Lomako Rivers.

As with other forest animals, it is difficult to assess population size and monitor trends in both species of chimpanzee. Attempts have been made to estimate overall population size by applying population density values at known sites to the remaining area of suitable habitat in the species range. Recent estimates of population size of western chimpanzee *P. troglodytes verus* indicate a total population size of between 25,500 and 52,900, possibly 78,000 of the central subspecies, and up to 117,700 of the eastern subspecies, although the numbers for each could be substantially lower (Table 1). The largest remaining populations occur in Central Africa, mainly in Gabon, Democratic Republic of Congo and Cameroon. Populations are extremely depleted in five countries (Ghana, Guinea-Bissau, Nigeria, Burundi and Rwanda), and another five countries (Senegal, Mali, the Cabinda enclave of Angola, Equatorial Guinea and Sudan) contain only small and dispersed remnant populations. Chimpanzees are now thought to be extinct in four of the 25 countries they once inhabited (Gambia, Burkina Faso, Togo and Benin). Estimates made in the 1980s and more recent estimates cannot easily be compared because in both cases they include a wide margin of uncertainty, but it is clear that numbers have declined substantially and populations almost everywhere are at risk.

Early speculative estimates of bonobo numbers (based on density of the more widespread common chimpanzee) suggested a total population of between 100,000 and 200,000 in the overall range. Other early estimates based on bonobo numbers at field study sites suggested a total population of as little as 10,000. Taking into account the fragmented distri-bution and recent impacts on the species, it has been suggested that present numbers are likely to be closer to the lower end of estimated numbers.

Given a lack of comprehensive and precise numerical population data, estimates of extinction risk are to a great extent based on observed loss or modification of chimpanzee habitats, on rates of exploitation, and also, in the case of the geographically restricted populations, on the risks inherent in a small range size. The Species Survival Commission of IUCN-The World Conservation Union in 2000 categorized both the chimpanzee and the bonobo as Endangered, i.e. facing a very high risk of extinction in the wild in the near future. In the former, each of the four subspecies is also categorized as Endangered.

Loss of suitable forest habitat is by far the greatest threat to both the chimpanzee and bonobo. This is caused by commercial logging, by conversion to agriculture, including cash crops and subsistence farming, by mineral prospecting and mining, and forest fires may also be significant. Progressive habitat loss often leaves small and unconnected patches in which chimpanzee and bonobo populations are isolated and at risk from chance demographic factors. Development of logging or mining operations invariably extends new access routes into undisturbed habitat, with a marked increase in hunting of animals for bushmeat, often followed by conversion for agriculture.

Deforestation is far advanced in West Africa, where only remnant tracts of primary rain forest persist. The fragmented populations of the eastern and western subspecies of common chimpanzee are primarily located in remnant forest, game reserves and national parks, but unauthorized hunting, logging, mining and farming are common in many nominally protected areas. The bonobo occurs in Salonga National Park (a World Heritage site), but this area is affected by civil unrest and increased hunting; elsewhere bonobos occur in a locally managed wildlife sanctuary in the Lukuru area of Democratic Republic of Congo.

Hunting of adults for bushmeat also has an impact on populations and is an important and increasing threat to both species. Bushmeat is often a major source of dietary protein in West and Central Africa, and sometimes also has perceived magical or medicinal benefits. Although hunting may locally be at sustainable levels, it increases with logging and mining because food is required to maintain large labour forces, and because colonizing human communities often favour bushmeat. Civil conflict also tends to increase hunting, often by people from other regions. The impact of bushmeat hunting is now more widespread because it is increasing rapidly in parallel with increasing access into remote areas, and new markets are being developed to serve rising demand among urban populations. Chimpanzee products are widely sold in local and regional markets, and trade in infant chimps is often associated with hunting of adults. Bonobos appear particularly sensitive to disturbance and are liable to move away from increasing contact with humans, as well as being particularly vulnerable to hunting with firearms.

The live animal trade, including capture of infants for the pet trade and entertainment industry, and the international biomedical trade, are additional pressures. It has been reported that around 1,000 wild-caught chimpanzees were exported from Africa annually during the past decade. Although much concern has in the past been expressed over such uses and the possible impact on wild populations, in itself this is far less a threat than habitat loss.

Both the common chimpanzee and bonobo are listed in Appendix I of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and trade in individuals or products is therefore subject to strict regulation by ratifying nations. Trade for primarily commercial purposes is banned. Both species are protected by law throughout their ranges, although enforcement is usually poor to non-existent. Both are listed in Class A of the African Convention (1969), which prohibits the hunting or capture of the species unless in the national interest or for scientific purposes.

Gorilla

Gorillas occur in a range of forest habitats in Africa (Fig. 1). Populations are grouped in two main regions: equatorial West Africa and eastern Central

Africa, but the number of actual species recognized is under review.

Until very recently, most taxonomists recognized a single species with three subspecies: the western and eastern lowland forms, and the highland form. In this system, the western lowland gorilla *Gorilla gorilla gorilla* is the most widespread subspecies, ranging from southeast Nigeria, Cameroon, the southwest corner of the Central African Republic, southward into west Congo, Equatorial Guinea, Gabon, and northern parts of the Cabinda enclave of Angola. There is a gap of around 1,000 km between these populations and Grauer's gorilla *G. g. graueri*, which is only known to occur in eastern Democratic Republic of Congo (although possibly present in the north). The mountain gorilla *G. g. beringei beringei* occurs on the extinct volcanoes forming the Virunga range along the borders of Rwanda, Uganda and Democratic Republic of Congo, and in the Bwindi-Impenetrable Forest National Park of southwest Uganda neighbouring Democratic Republic of Congo.

More recently, a number of primatologists have recognized western and eastern populations as separate full species, *Gorilla gorilla* and *Gorilla beringei* respectively. In the western group, the isolated Nigeria-Cameroon gorillas are now recognized as a subspecies, Cross River gorilla *G. g. diehli*, and there is much divergence even within this subgroup. The eastern group includes both the lowland and the mountain populations (among the latter the Bwindi gorillas may form a fifth subspecies).

There is no reliable estimate of the total population of wild gorillas. Recent forest surveys in Gabon and Congo have established that western lowland gorillas may occur at higher densities and in a wider range of forest habitats than was previously thought, and the total population of this group may number 94,700 individuals. It was thought during the 1980s that around 1,500 gorillas occurred in the Nigeria-Cameroon (Cross River) region, but a recent estimate suggests only 150-200 remain, split into five populations, each isolated on a separate hill area. Grauer's gorilla had been estimated during the 1980s to comprise 3,000-5,000 individuals, all in Democratic Republic of Congo, but information on distribution was incomplete and others have suggested that numbers may approach 16,900. Recent estimates suggest that around 320 mountain gorillas remain, with slightly more in the Virungas than the Bwindi area. Given a general lack of comprehensive numerical population data, estimates of extinction risk are to a great extent based on observed loss or modification of gorilla habitats, on rates of exploitation, and also, in the case of the geographically restricted forms, on the risks inherent in a small range size.

The Species Survival Commission of IUCN-The World Conservation Union has adopted the new taxonomy, and has categorized both western gorilla and eastern gorilla (*G. beringei*) as Endangered overall, i.e. facing a very high risk of extinction in the wild in the near future. Three particular populations are categorized as Critically Endangered, i.e. facing an extremely high risk of extinction in the wild in the immediate future; these are the Cross River form in the far west, and both the mountain and Bwindi forms in the far east.

Habitat loss or degradation have been regarded as the major threats to gorilla populations, but much recent concern has been focused on the bushmeat trade, and the impact of civil conflict within the range of gorillas. Forest is being converted to crop production and livestock grazing in many parts of Africa. In West Africa, commercial logging and petroleum exploitation have been cited as increasingly significant threats to gorilla habitat. Where new routes are opened up for timber or mineral extraction, exploitation of forest animals for food use (bushmeat) rises in order to support the incoming labour force, and civil conflict can have the same effect. In eastern parts of Democratic Republic of Congo a recent increase in mining activity has badly impacted habitats and wildlife in key protected areas. Although bushmeat is culturally and nutritionally important in many regions, concern has been expressed recently about the intensity and extent of the bushmeat trade, and its adverse impacts on wild populations. The impact of bushmeat hunting is now more widespread and serious because it is increasing rapidly in parallel with increasing access into remote areas, and new markets are being developed to serve rising demand among urban populations.

International trade in live gorillas and gorilla products, formerly a significant threat to the species, has greatly declined since the gorilla was listed on Appendix I of CITES in 1977. National laws for control of hunting and capture exist in all countries with

gorilla populations, but lack of funds and inaccessibility make wide enforcement of this legislation impractical. In the dry season when food is scarce gorillas frequently raid crops, and may be hunted at this time. In places, gorilla products are sometimes used for traditional magical or medicinal purposes. Gorillas are also liable to be maimed or killed by traps and snares intended for other animals.

Current status and distribution of Southeast Asian great apes

Much of the information presented here is derived from the recent accounts presented by Rijksen and Meijaard (1999) and Yeager (1999).

Orangutan

Orangutans are the only great apes outside Africa, and occur in forested habitats on the islands of Borneo and Sumatra. Fossil material indicates that orangutans were formerly widespread in continental Southeast Asia. All extant populations had until recently been regarded as a single species *Pongo pygmaeus*, but after analysis of mitochondrial DNA it was proposed in 1996 that the genetic divergence between orangutans from Borneo and those from Sumatra was sufficiently marked that orangutans on each island should be treated as separate species: the Bornean orangutan *Pongo pygmaeus* and the Sumatran orangutan *P. abelii*.

The Bornean orangutan occurs in forests in two of the three nations sharing the island: Indonesia (Kalimantan) and Malaysia (Sabah, Sarawak), but its presence in Brunei is unconfirmed. Recent analysis of morphological data suggests that three subspecies may exist (Groves 2002): *Pongo pygmaeus pygmaeus* is medium-sized and occurs in northwest Kalimantan and Sarawak; the largest subspecies, *P. p. wurmbii*, is found in southwest Kalimantan, and the smallest, *P. p. morio*, occurs in Sabah and east Kalimantan. Rivers form the main barriers between these divisions. The Sumatran orangutan occurs only in the provinces of Aceh and Sumatera Utara in northern Sumatra, Indonesia.

As with other forest animals, it is difficult to assess orangutan population size and monitor trends. In the late 1980s the total population was tentatively estimated at approaching 180,000; this figure was derived by multiplying a value for species density by an estimate of the remaining area of habitat. In 1990, the IUCN/SSC Primate Specialist Group estimated that there were approximately 30,000 to 50,000 orangutans remaining in the wild, but cautioned that these figures may have been overestimates.

Recent analyses have estimated respective declines of 97% and 86% in Bornean and Sumatran orangutans during the last century; the future of the two species is therefore of serious concern. The Bornean orangutan was classified as critically endangered and the Sumatran as endangered by IUCN in 2000 (Hilton-Taylor 2000).

Although Bornean orangutans currently outnumber Sumatran orangutans, patterns of decline and habitat loss suggest the Bornean species will undergo a more rapid decline and without intervention their numbers may drop below that of the Sumatran species. Recent estimates suggest that 15,000 Bornean orangutans currently survive in increasingly fragmented forest totalling little more than 100,000 km^2 in area. Under current trends and with just 17% of orangutan range currently protected (14 fragments supporting 3,240 individuals) it is expected that only 10-15% of this population will survive in the long term. Approximately 12,500 Sumatran orangutans are thought to exist in 26,000 km^2 of forest. A decline of 50% was predicted to occur between 1991 and 1999. This trend is expected to continue (Hilton-Taylor 2000), but the current protected area (42%, 5,400 individuals) should support 60% of the present population.

Habitat loss, fragmentation and degradation are the major concerns threatening orangutan survival. Human activities (logging, mining, plantations, agriculture, road building, industrial development etc.) have caused the loss of anywhere between 25 and 50% of suitable orangutan habitat depending on region and less than 14% of the official conservation and protected forest is suitable ape habitat. Official timber concessions almost completely overlap the fragmented distribution range of the orangutan in Kalimantan and northern Sumatra. In eastern Malaysia large areas have been converted for plantations and logging has reportedly increased considerably during the last 10 years; 86% of forest land was conceded for timber concessions in 1986.

Fires and droughts have ravaged Kalimantan repeatedly over the past two decades and fires began burning again in 2002. Significant fire damage last occurred in 1997 and 1998, affecting 25-60% of

orangutan habitat (depending on region). Localized damage was extreme; in Kutai National Park 95% of lowland forest was lost (Yeager 1999). The disproportionate loss of peat swamp and lowland forest was the most serious consequence since this is key habitat for orangutans. As a result of the fires, Rijksen and Meijaard (1999) believe Borneo's population was reduced from 23,000 in 1996 to 15,400 in 1998 – a decline of 33% in just one year. Fire and drought appear to be relatively new threats in Sumatra, and have not yet been considered as serious threats for the Sumatran species. Approximately 5% of the 1997-1998 fire hotspots occurred within their habitat on this island. Habitat degradation is more of a concern in Sumatra since almost twice the current population could be supported if the forest was not degraded.

Orangutans are unable to survive long term in degraded and fragmented forests. Their fruit-dominated diet requires them to occupy large ranges to ensure sufficient supplies and some individuals commute between feeding sources. Devastated forests offer few fruit resources and orangutans are forced out to roam in search of food. Large numbers were massacred while fleeing the flames and smoke during and after the extensive forest fires of 1997 and 1998. The displacement of apes can cause a 'shock wave' of refugee crowding in adjacent forests. This overcrowding can lead to increased physiological and psychological stress, which can have negative impacts on reproduction. Similarly, orangutans do not cope well with selective logging. Selectively logged forest and old secondary growth contain only 30-50% of the orangutan density found in primary forest.

Fragmentation of habitat also has serious consequences for genetic variability. For a genetically healthy population of at least 500 individuals a minimum of 1,000 km^2 in Borneo and 600 km^2 in Sumatra are required (a higher density of large fruit sources in Sumatra allows higher orangutan densities). On the basis of this criterion only six orangutan populations in Sumatra and 13 in Kalimantan inhabit forest blocks large enough to be relatively free of a direct fragmentation impact. Only three populations in Sabah and one in Sarawak reach this criterion.

Orangutans are a protected species over their entire distributional range and all hunting is illegal. Nevertheless, poaching is common in both Borneo and Sumatra. Poaching safaris (by army and industrial elites) reportedly take place and hunting is still common in rural and forest communities. Loss of females is the key concern. Adult females are found at higher densities than adult males, and thus are more likely to be targets for hunters. Moreover, adult females are typically killed to capture their infant for the pet trade. Losses due to hunting and the pet trade may be sizeable and recent reports indicate an increase in poaching, primarily as a response to the economic crisis in Indonesia. There is a regular trade in apes to ports in Java, Singapore, Bangkok, Hong Kong and Taiwan. Habitat loss due to fires has exacerbated this problem, since it drives animals into increased contact with humans.

Annex 2
GLOBIO, GRASP and the World Atlas of Great Apes

GRASP partners

United Nations Environment Programme (UNEP); United Nations Educational, Scientific and Cultural Organization (UNESCO); African Wildlife Foundation (AWF); Ape Alliance; Born Free Foundation; Bristol Zoo Gardens; Bushmeat Crisis Task Force; Conservation International (CI); Convention on Biological Diversity (CBD); Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); Convention on Migratory Species (CMS); Dian Fossey Gorilla Fund; Fauna and Flora International (FFI); International Fund for Animal Welfare (IFAW); International Gorilla Conservation Programme (IGCP); Institute for Tropical Forest Conservation; Jane Goodall Institute (JGI); Orangutan Foundation; Pan African Sanctuaries Alliance (PASA); UNEP World Conservation Monitoring Centre (UNEP-WCMC); Wild Chimpanzee Foundation (WCF); Wildlife Conservation Society (WCS), World Wide Fund for Nature (WWF).

GLOBIO

GLOBIO ('Global methodology for mapping human impacts on the biosphere') is being developed for and together with the United Nations Environment Programme (UNEP) to assess and map the current and possible future impacts of human expansions on the environment and biodiversity at local, regional and global scales. The method has been applied to assist in the development of scenarios of global environmental change, as part of UNEPs third *Global Environment Outlook (GEO-3)*.

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Great Apes Survival Project

UNEP is aware of the urgent need for commitment – at the highest levels – to ensure the survival of great apes. UNEP, together with CITES, the Convention on Migratory Species (CMS), the Convention on Biological Diversity (CBD), the African Wildlife Foundation, the Ape Alliance, Born Free Foundation, Bristol Zoo Gardens, Conservation International, Fauna and Flora International, the Orangutan Foundation, the Wild Chimpanzee Foundation, WWF and other partners, will endeavour to bring world-wide attention to the ape crisis, raise funds for conservation, and develop a global conservation strategy for all great ape populations.

The Executive Director of UNEP has appointed three UN Special Envoys for Great Apes supported by a small team, to visit each range state and obtain endorsements at the highest political level for improved protection, strengthened support for conservation and the preparation and adoption of National Great Ape Survival Plans. In addition to seeking political support for great ape conservation, the Special Envoy team will give particular priority to fundraising activities for the priority activities identified by the national plans.

There are 23 countries with naturally occurring populations of great apes. Orangutans are found in two countries, gorillas in nine, chimpanzees in 21 (all those with gorillas also have chimpanzees) and bonobos in just one (the Democratic Republic of Congo). In each state, GRASP will identify what needs to be done to ensure the survival of its ape populations. In addition, conservation effort is often applied in a piecemeal fashion, where opportunities present themselves and resources are available. Such efforts would have a greater impact if they were part of a systematic prioritized approach. The strategies must also be integrated with the development objectives of range states and be sympathetic to the needs of local communities.

The strategies recommended in each National Great Ape Survival Plan (NGASP) will give cohesion to the existing work of many agencies, organizations and

individuals; this should enable resources to be targeted more effectively and identify areas currently neglected. The project will enable agencies and organizations to access a wide range of funding opportunities in the state, charitable and commercial sectors.

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The World Atlas of Great Apes

The UNEP World Conservation Monitoring Centre is coordinating the compilation of a *World Atlas of Great Apes*, in support of the Great Apes Survival Project (GRASP).

The *World Atlas of Great Apes* will provide a comprehensive review of what is currently known about the great apes, including a description of their ecology and distribution and the key threats that they face. The book will include an assessment of the current status of great ape species in each of the countries where they are found, together with an overview of current conservation action and priorities, illustrated by maps. Furthermore, the atlas will highlight the importance of great apes to people.

The atlas will be of interest to the general public, as well as conservation groups, NGOs, governments, intergovernmental organizations, adademia and students. It will raise the international profile of great ape conservation efforts, and help guide future action. In particular, the atlas will support the development of National Great Ape Survival Plans (NGASPs) in each range state. This will be achieved by inclusion of distribution maps, information on specific threats facing apes, and priorities for conservation action, for each of the 23 range states.

UNEP-WCMC has many years experience of producing conservation atlases, including most recently the highly successful *World Atlas of Coral Reefs*, and the *World Atlas of Biodiversity*, both published by the University of California Press. These publications have been designed to present technical information in a highly accessible format, through the extensive use of maps, diagrams and illustrations.

The *World Atlas of Great Apes* will be produced in close collaboration with the Born Free Foundation, together with other key organizations and individuals active in great ape conservation.

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